

1997-1999 GREEN BAY METROPOLITAN AREA
INTERSECTION CRASH STUDY

Adopted by the Brown County Planning Commission Board of Directors
February 7, 2001

I. Introduction

The Green Bay metropolitan area experiences hundreds of vehicle crashes every year that are caused by a variety of factors, and most of these crashes occur at intersections because these are the main conflict points in the street system. This study examines the 30 metropolitan area intersections that experienced at least 15 reportable crashes and had the highest average annual crash rates between 1997 and 1999 to determine the primary causes for the incidents and methods of correcting many of the major problems that appear to exist at the intersections. The study does not include the metropolitan area freeway interchanges because reliable crash rates could not be calculated using the available information. After discussing this issue with Wisconsin Department of Transportation (WisDOT) traffic engineers, planning commission staff determined that a separate study could be conducted in the future to collect the detailed information necessary to calculate accurate crash rates and develop reliable recommendations for the interchanges.

The information for this study was obtained from the WisDOT Bureau of Highway Operations in Madison and through several reviews of each intersection in the report. Despite being difficult to sort by intersection, the WisDOT records are very extensive and provide a very detailed summary of the information provided on the forms completed by law enforcement officers at the scene of every reportable crash. The summary information, field visits, and the experience of observing and using many of the intersections on a daily basis enabled staff to develop reliable observations and recommendations for the study.

II. Explanation of Terms Used in the Study

Crash Rate

The crash rates that were calculated for the intersections using WisDOT's most recent traffic counts (1998) represent the number of crashes that occurred for every million vehicles that entered each intersection in a year. The intersections were ranked by crash rate because this was assumed to be the most appropriate indication of safety problems, but many intersections with relatively low rates experienced several property damage and injury crashes throughout the three year study period and should not be disregarded merely because of their lower rates. The average annual number of crashes experienced by the intersections in the study and the intersections' annual crash rates are shown in Maps 1 and 2.

Reportable Crashes Per Year

This study only considers crashes that are considered to be reportable by the law enforcement officer that was at the scene because these are believed to be the most severe and are the incidents that are submitted to the crash records division of the Wisconsin Department of Transportation in Madison. For a crash to be reportable, an

officer has to believe that a vehicle has sustained a minimum of \$1,000 damage. Crashes where less damage has occurred are typically noted by officers but are not filed with the WisDOT crash records division.

Estimated Property Damage Cost Per Year

The property damage cost associated with crashes at each intersection was calculated using a per crash estimate of \$6,400 that was developed by the National Safety Council (NSC) in 1997.

Injuries Per Year

This statistic identifies the average number of people that were injured at each intersection per year over the three year study period.

Estimated Injury Cost Per Year

The injury cost associated with crashes at each intersection was calculated using a per injury estimate of \$34,100 that was developed by the NSC in 1997. The injury and property damage cost estimates illustrate the economic toll of crashes and provide financial justification for spending money to change the physical characteristics of dangerous intersections.

Crash Type

The crash reports provided by WisDOT identify several types of crashes, but this study concentrates on angle, rear end, head on, and side swipe crashes because these were usually the most common and severe types of crashes at each intersection. The study also notes the percentage of crashes that involved pedestrians and bicycles to determine if the intersections are unsafe for these transportation modes.

Driver Factor

The WisDOT reports also identify several factors that caused the intersection-related crashes, but this study concentrates on crashes that involved drivers disregarding traffic controls, failing to yield, driving inattentively, and traveling too fast for conditions. The study also notes the percentage of crashes that were caused by the condition of the drivers, which typically meant that one or more of the drivers was under the influence of alcohol or another substance.

Comments

The comments for the intersections are based on an extensive review of the crash data and visits to the intersections to identify problems and confirm the existence of hazards.

Recommendations

The report recommends remedies to the problems that are believed to exist at the study's 30 intersections. Since these recommendations often involve changes in the intersection's physical characteristics, the recommendations should be reviewed by a certified engineer before the corrections are made.

III. Intersection Analysis

1. Madison Street/Cherry Street (Green Bay)

Crash Rate	2.42
Reportable Crashes Per Year	5.3
Est. Property Damage Cost/Year	\$33,920
Injuries Per Year	2.7
Est. Injury Cost/Year	\$92,070
Crash Type	
Right Angle	88%
Rear End	0%
Side Swipe	6%
Head On	0%
Bicycle/Pedestrian	0%
Other	6%
Driver Factor	
Disregard Traffic Control	60%
Failure To Yield	6%
Inattentive Driving	13%
Too Fast For Conditions	0%
Driver Condition	0%
Other	21%



Comments: Despite the relatively low number of reportable crashes, the intersection of Madison Street and Cherry Street had one of the highest crash rates in the metropolitan area between 1997 and 1999 because of its relatively low daily traffic volume. The data for this intersection suggest that nearly all of the crashes are right angles that are usually caused by northbound (Madison) motorists disregarding the traffic light and that most of the crashes result in only property damage. The disregard for the traffic control is likely a result of motorists trying to beat the red light at this intersection to travel from Walnut Street to Pine or Main without stopping.

Recommendations: The number of crashes at the Madison/Cherry intersection would probably decrease significantly if Madison were narrowed and converted to a two directional facility because opposing traffic and increased side friction would slow the Madison motorists down and make them less likely to try to beat the light. Converting Cherry to a two directional street appears to have reduced vehicle speeds and conflicts with intersecting traffic, so this should be considered for Madison as well.

2. University Avenue/Elizabeth Street (Green Bay)

Crash Rate	2.11
Reportable Crashes Per Year	14.3
Est. Property Damage Cost/Year	\$91,520
Injuries Per Year	9.7
Est. Injury Cost/Year	\$330,770
Crash Type	
Right Angle	44%
Rear End	30%
Side Swipe	14%
Head On	5%
Bicycle/Pedestrian	0%
Other	7%
Driver Factor	
Disregard Traffic Control	5%
Failure To Yield	51%
Inattentive Driving	18%
Too Fast For Conditions	12%
Driver Condition	2%
Other	12%



Comments: The most common (and severe) incidents at this intersection were angle crashes that occurred on University Avenue when eastbound and westbound motorists turned left in front of oncoming vehicles. The intersection also experienced several rear end crashes that appear to have been caused by slippery streets and drivers that were not paying attention (especially during the weekday afternoons).

Recommendations: Since a left turning motorist's inability to see oncoming traffic appears to be the cause of nearly 40 percent of the crashes at this intersection, the signals regulate traffic relatively inefficiently because of the intersection's fifth leg (Day Street), and approaching motorists apparently have trouble paying attention and traveling at appropriate speeds during poor weather, the intersection could be made much safer and more efficient if the signals were replaced with a five leg roundabout. However, if this is not feasible due to space constraints, many of the crashes could be eliminated by constructing offset left turn lanes that allow motorists making left turns to easily see vehicles approaching in the opposing through lanes. The offset lanes are illustrated in Figure 1 at the end of the report.

3. Walnut Street/Roosevelt Street (Green Bay)

Crash Rate	1.99
Reportable Crashes Per Year	6
Est. Property Damage Cost/Year	\$38,400
Injuries Per Year	6.7
Est. Injury Cost/Year	\$228,470
Crash Type	
Right Angle	66%
Rear End	10%
Side Swipe	6%
Head On	6%
<u>Bicycle/Pedestrian</u>	6%
Other	6%
Driver Factor	
Disregard Traffic Control	11%
Failure To Yield	33%
Inattentive Driving	22%
Too Fast For Conditions	0%
Driver Condition	17%
Other	17%



Comments: At first glance, it appears that the likelihood of being injured during a crash at this intersection is relatively great because of the high number of injuries. However, removing the twelve injuries that occurred during three alcohol-related crashes reduces this number significantly. These incidents aside, the most common crashes at the intersection were angle crashes that occurred when northbound (Roosevelt) motorists pulled out in front of eastbound and westbound motorists on Walnut. Also, the vast majority of the crashes at this intersection happened between 1:00 and 5:00 on weekday afternoons.

It is possible that some of these crashes happened due to visibility problems caused by trees at the intersection’s southwest corner or vehicles waiting to turn right in the northbound right turn lane. These visibility problems could have caused motorists to guess when adequate gaps were present, quickly accelerate into small gaps in the heavy weekday afternoon flow, and get hit before reaching the other side.

Recommendations: It is possible that some of the crashes could be eliminated by removing the right turn lane at Roosevelt’s northbound approach and possibly removing a tree at the southwest corner to improve visibility, but these changes will not address the other issues at the intersection. A single lane roundabout, however, would address the visibility and traffic control issues at the intersection, eliminate most of the crashes and nearly all of the injuries, and even minimize the damage that could be caused by future alcohol-related crashes. Since the number of vehicles entering the intersection each day is likely below 10,000, a single lane roundabout could easily handle the traffic load. A roundabout would certainly enhance safety, make the area more pedestrian and bicycle friendly, and improve the area’s appearance without compromising traffic flow on Walnut Street.

4. Madison Street/Crooks Street (Green Bay)

Crash Rate	1.93
Reportable Crashes Per Year	5
Est. Property Damage Cost/Year	\$32,000
Injuries Per Year	3.7
Est. Injury Cost/Year	\$126,170
Crash Type	
Right Angle	85%
Rear End	0%
Side Swipe	15%
Head On	0%
Bicycle/Pedestrian	0%
Other	0%
Driver Factor	
Disregard Traffic Control	36%
Failure To Yield	50%
Inattentive Driving	0%
Too Fast For Conditions	0%
Driver Condition	0%
Other	14%



Comments: According to the data for this intersection, almost every reportable crash occurred at a right angle while both vehicles were driving straight and was caused by a vehicle on Crooks pulling into the path of a vehicle traveling north on Madison. Since the intersection is very wide and vehicles are able to travel relatively fast on Madison, it is likely that most (if not all) of the crashes were the result of vehicles being unable to get across the intersection before encountering an oncoming vehicle in one of Madison Street's many travel lanes.

Recommendations: Madison Street should be converted to a two-way street and narrowed to minimize the distance drivers, pedestrians, and bicyclists have to cross and to encourage drivers on Madison to travel through the area at slower speeds. Since Crooks is a popular means of traveling between Monroe Avenue and Washington Street, the city should also consider placing a roundabout at the intersection to make it safer, more efficient, and more attractive.

5. West Mason Street/Taylor Street (Green Bay)

Crash Rate	1.87
Reportable Crashes Per Year	24
Est. Property Damage Cost/Year	\$153,600
Injuries Per Year	21.7
Est. Injury Cost/Year	\$739,970
Crash Type	
Right Angle	67%
Rear End	25%
Side Swipe	3%
Head On	1%
Bicycle/Pedestrian	1%
Other	3%
Driver Factor	
Disregard Traffic Control	33%
Failure To Yield	32%
Inattentive Driving	15%
Too Fast For Conditions	8%
Driver Condition	0%
Other	12%



Comments: The most common (and severe) incidents at this intersection were angle crashes that occurred on Mason Street when eastbound and westbound motorists turned left in front of oncoming vehicles and when Mason motorists disregarded the traffic signal and hit northbound and southbound Taylor motorists.

It is difficult to determine why motorists disregard the signals so frequently, but it is likely that many drivers try to avoid being stopped at the intersection but fail to beat the red light and that some westbound motorists are ignoring the Taylor lights as they concentrate on positioning themselves to enter US 41. The crashes caused by left turning vehicles pulling in front of vehicles traveling straight are probably due to the inability of left turners to see traffic approaching from the opposite direction because their view is obstructed by opposing left turners. This situation appears to be common at many of the intersections in this study and, in this case, should be relatively easy to correct.

Recommendations: The problems addressed above could be corrected with a roundabout at the Mason/Taylor intersection, and this roundabout would be even more effective if roundabouts were built at the two Mason/US 41 ramp intersections to the west. A roundabout at Mason and Taylor would also make the intersection much safer for pedestrians and bicyclists, improve the attractiveness of the area, and would quickly pay for itself by significantly reducing property damage and injuries. However, if a roundabout is not feasible, a more immediate method of solving the left turning problems would be to construct offset left turn lanes in the Mason Street medians to enable motorists to easily see oncoming vehicles (see Figure 1).

6. Lombardi Avenue/Marlee Lane (Ashwaubenon & Green Bay)

Crash Rate	1.82
Reportable Crashes Per Year	18.7

Est. Property Damage Cost/Year	\$119,680
Injuries Per Year	18
Est. Injury Cost/Year	\$613,800
Crash Type	
Right Angle	46%
Rear End	48%
Side Swipe	4%
Head On	0%
Bicycle/Pedestrian	0%
Other	2%
Driver Factor	
Disregard Traffic Control	5%
Failure To Yield	38%
Inattentive Driving	16%
Too Fast For Conditions	11%
Driver Condition	2%
Other	28%



Comments: The most common incidents at this intersection were angle crashes that occurred when motorists traveling in all four directions turned left in front of oncoming vehicles and eastbound rear end crashes that were almost entirely caused by inattentive driving and poor weather conditions. Like at many of the other intersections in this study, it is likely that the left turn crashes at Lombardi/Marlee were caused by the inability of left turning motorists to see oncoming vehicles before making their turns. The rear end crashes are more difficult to explain, but the extremely high proportion of eastbound crashes (many of which occurred on weekday afternoons) suggests that people are continuing to drive fast after exiting US 41 and are suddenly encountering vehicles stacked at the Marlee signal.

Recommendations: A relatively low cost method of making left turns safer on Lombardi Avenue would be to construct offset left turn lanes in the Lombardi medians to enable motorists to easily see oncoming vehicles (see Figure 1). Many of the rear end crashes could also be eliminated by encouraging eastbound Lombardi motorists to drive slower by narrowing each of the street's four lanes to eleven feet and curbing the outside of the street to make it feel less like a highway and more like a city street.

Another option that would significantly reduce conflicts at the Lombardi/Marlee and Lombardi Access/Marlee intersections would be to construct a six leg roundabout that includes both Lombardi approaches, both Marlee approaches, and both Lombardi Access approaches. Bringing all of these streets into one roundabout would address all of the safety problems at the intersections, increase traffic flow and capacity, make the intersections more pedestrian and bicycle friendly, and improve the area's appearance.

7. STH 172/Babcock Road (Ashwaubenon)

Crash Rate	1.65
Reportable Crashes Per Year	15.7
Est. Property Damage Cost/Year	\$100,480
Injuries Per Year	8
Est. Injury Cost/Year	\$272,800
Crash Type	
Right Angle	55%
Rear End	23%
Side Swipe	6%
Head On	2%
Bicycle/Pedestrian	0%
Other	14%
Driver Factor	
Disregard Traffic Control	17%
Failure To Yield	45%
Inattentive Driving	15%
Too Fast For Conditions	4%
Driver Condition	0%
Other	19%



Comments: The most common (and severe) incidents at this intersection during the three year period were angle crashes that happened when vehicles traveling straight hit vehicles making left turns, and most of these crashes and nearly all of the injuries occurred on STH 172. Most of the crashes happened during the weekday afternoon and morning peak travel periods.

Recommendations: A relatively low cost method of making left turns safer on STH 172 would be to construct offset left turn lanes in the STH 172 medians to enable motorists to easily see oncoming vehicles (see Figure 1). Another option that would significantly reduce conflicts at the STH 172/Babcock intersection would be to construct a roundabout. A roundabout would address all of the safety problems at the intersection, increase traffic flow and capacity, make the intersection more pedestrian and bicycle friendly, and improve the area's appearance.

8. Irwin Avenue/Radisson Street (Green Bay)

Crash Rate	1.60
Reportable Crashes Per Year	5.3
Est. Property Damage Cost/Year	\$33,920
Injuries Per Year	4.3
Est. Injury Cost/Year	\$146,630
Crash Type	
Right Angle	75%
Rear End	19%
Side Swipe	6%
Head On	0%
Bicycle/Pedestrian	0%
Other	0%
Driver Factor	
Disregard Traffic Control	0%
Failure To Yield	63%
Inattentive Driving	25%
Too Fast For Conditions	0%
Driver Condition	0%
Other	12%



Comments: Until May of 1999, the Irwin/Radisson intersection was controlled by stop signs at the Radisson approaches. Judging by the data for the intersection, many of the crashes were caused by vehicles on Radisson pulling into the path of vehicles traveling north and south on Irwin. Since the intersection is relatively wide, vehicles were able to travel reasonably fast on Irwin, and many of the vehicles involved in the crashes were trucks, it is likely that most of these crashes were the result of trucks being unable to enter or cross the intersection in time to avoid collisions. Even though two rear end crashes occurred at the new Irwin stop signs in 1999, the conversion of the intersection to a four way stop appears to have reduced the total number of right angle crashes from six in 1998 to one in 1999.

Recommendations: The four way stop seems to have improved traffic safety at the intersection, but the city should monitor the intersection to determine if the number of crashes continues to remain low.

9. Ashland Avenue/Cormier Road (Ashwaubenon)

Crash Rate	1.59
Reportable Crashes Per Year	16.3
Est. Property Damage Cost/Year	\$104,320
Injuries Per Year	12
Est. Injury Cost/Year	\$409,200
Crash Type	
Right Angle	46%
Rear End	24%
Side Swipe	4%
Head On	0%
Bicycle/ <u>Pedestrian</u>	2%
Single Vehicle Crash	24%
Other	0%
Driver Factor	
Disregard Traffic Control	10%
Failure To Yield	36%
Inattentive Driving	16%
Too Fast For Conditions	18%
Driver Condition	2%
Other	18%



Comments: The most common (and severe) incidents at this intersection during the three year study period were angle crashes that happened when vehicles traveling straight hit vehicles making left turns, and most of these crashes occurred when a southbound left turner pulled in front of a northbound vehicle. The left turn crashes were responsible for 18 of the intersection's 36 injuries between 1997 and 1999.

The next most common crash appears to have been motorists hitting fixed objects at the intersection. Of the twelve fixed object crashes recorded at the intersection, eight were collisions with traffic signals that did not involve alcohol or poor driving conditions, and six of the traffic signal crashes were caused by northbound drivers making right turns. This is not surprising, for the signal and a utility pole at this corner are located virtually on the curb.

Recommendations: Many of the crashes and injuries at the intersection would likely be eliminated by constructing offset left turn lanes in the existing Ashland Avenue medians (see Figure 1). This project should be relatively inexpensive because adequate space exists between the northbound and southbound lanes, and the money saved by reducing crashes and injuries at the intersection would pay for the improvements in very little time. The traffic signal and utility pole at the intersection's southeast corner should also be moved back several feet to eliminate these hazards.

10. Main Street/Auto Plaza Way (Green Bay)

Crash Rate	1.55
Reportable Crashes Per Year	13
Est. Property Damage Cost/Year	\$83,200
Injuries Per Year	8.3
Est. Injury Cost/Year	\$283,030
Crash Type	
Right Angle	74%
Rear End	10%
Side Swipe	5%
Head On	0%
Bicycle/Pedestrian	3%
Other	8%
Driver Factor	
Disregard Traffic Control	23%
Failure To Yield	49%
Inattentive Driving	15%
Too Fast For Conditions	5%
Driver Condition	0%
Other	8%



Comments: The most common incidents at this intersection were angle crashes that occurred when vehicles on the east Main Street frontage road pulled out in front of vehicles traveling east or west on Auto Plaza Way. In almost every instance, the Main frontage road vehicles appeared to have been trying to cross Auto Plaza Way to reach the opposing frontage road. These crashes were likely a result of the frontage road motorists trying to cross several lanes of fast moving traffic on Auto Plaza Way by quickly accelerating into what were believed to be adequate gaps and getting hit before reaching the other side of the street.

Recommendations: The data suggest that more than a third of the crashes at the Main/Auto Plaza Way intersection could be eliminated if motorists approaching Auto Plaza Way on the east frontage road were only allowed to make right turns. Left turns onto the frontage road from Auto Plaza Way could still be allowed since they do not appear to cause many crashes, but frontage road motorists that want to turn left or go straight would be forced to use the other streets to the north and south. This issue is discussed further in the Conclusions section of the study.

11. Monroe Avenue/Cherry Street (Green Bay)

Crash Rate	1.51
Reportable Crashes Per Year	8
Est. Property Damage Cost/Year	\$51,200
Injuries Per Year	6.3
Est. Injury Cost/Year	\$214,830
Crash Type	
Right Angle	88%
Rear End	8%
Side Swipe	0%
Head On	0%
Bicycle/ <u>Pedestrian</u>	4%
Other	0%
Driver Factor	
Disregard Traffic Control	58%
Failure To Yield	4%
Inattentive Driving	25%
Too Fast For Conditions	0%
Driver Condition	0%
Other/Blank	13%



Comments: The most common incidents at this intersection were angle crashes that happened when both vehicles were traveling straight, and the vast majority of these incidents were caused by southbound Monroe drivers running the red light and hitting eastbound vehicles on Cherry. Since all of the vehicle crashes during this period occurred when Cherry was a one way street, a typical crash was probably one that happened when a southbound motorist tried to beat the red light, wound up running it, and hit an eastbound motorist as the motorist was accelerating into the intersection as soon as the light turned green (which was common when Cherry was a one way street). The high speeds on Monroe, rapid acceleration of vehicles from Cherry, and proximity of the southbound and eastbound vehicles at the intersection left motorists very little time to avoid the crashes.

The reduction of crashes at the intersection after July of 1999 probably has a lot to do with Cherry Street's conversion to a two way street, for vehicles now enter the intersection from Cherry more slowly because of the presence of opposing traffic. In many cases, eastbound and westbound vehicles are unable to enter the intersection until the vehicles in front of them make left turns. This increased friction appears to have improved reaction time and, as a result, a motorist's ability to avoid crashes.

Recommendations: The intersection should be monitored for the next three years to determine if the Cherry Street traffic pattern change has made the intersection safer.

12. West Mason Street/Packerland Drive (Green Bay)

Crash Rate	1.49
Reportable Crashes Per Year	18.3

Est. Property Damage Cost/Year	\$117,120
Injuries Per Year	9.7
Est. Injury Cost/Year	\$330,770
Crash Type	
Right Angle	64%
Rear End	18%
Side Swipe	7%
Head On	2%
Bicycle/ <u>Pedestrian</u>	4%
Other	5%
Driver Factor	
Disregard Traffic Control	2%
Failure To Yield	64%
Inattentive Driving	12%
Too Fast For Conditions	2%
Driver Condition	2%
Other	18%



Comments: The most common incidents at this intersection were angle crashes that occurred when vehicles on the West Mason frontage roads pulled out in front of vehicles traveling north or south on Packerland Drive. In almost every instance, the West Mason frontage road vehicle was attempting to make a left turn onto Packerland or was trying to cross Packerland to reach the opposing frontage road. These crashes were likely the result of the frontage road motorists trying to cross several lanes of fast moving traffic on Packerland by quickly accelerating into what were believed to be adequate gaps and getting hit before entering the flow or reaching the other side of the street.

Recommendations: The data suggest that over half of the crashes at the West Mason/Packerland intersection could be eliminated if motorists entering Packerland Drive from the frontage roads were only allowed to make right turns. Left turns onto the frontage roads from Packerland could still be allowed since they do not appear to cause many crashes, but frontage road motorists that want to turn left or go straight should be forced to use the other streets to the east and west. A possible negative impact of this action, however, is that motorists on the east frontage road might cut through the Grand Central Station parking lot to reach Packerland Drive. This temptation could possibly be lessened by reducing the size of the gas station's driveways, but some cutting through would still likely occur. These issues are discussed further in the Conclusions section of the study.

13. East Mason Street/Lime Kiln Road (Green Bay)

Crash Rate	1.46
Reportable Crashes Per Year	12.7
Est. Property Damage Cost/Year	\$81,280
Injuries Per Year	9
Est. Injury Cost/Year	\$306,900
Crash Type	
Right Angle	53%
Rear End	32%
Side Swipe	5%
Head On	3%
Bicycle/Pedestrian	0%
Other	7%
Driver Factor	
Disregard Traffic Control	16%
Failure To Yield	26%
Inattentive Driving	21%
Too Fast For Conditions	7%
Driver Condition	11%
Other	19%



Comments: The most common incidents at this intersection were angle crashes that occurred when motorists traveling in all four directions turned left in front of oncoming vehicles. Rear end crashes were also fairly common, and all but one of these crashes occurred at the eastbound and northbound approaches. Also, alcohol was a factor in 21 percent of the crashes and 33 percent of the injuries during the three year study period. The high number of alcohol-related crashes at the intersection could be related to the high concentration of taverns in the area.

Recommendations: The city should stagger the left turning vehicles so approaching vehicles can be seen well before reaching the intersection (see Figure 1). On Lime Kiln, this could be accomplished by restricting the two inside lanes of Lime Kiln to left turns and forcing all through and right movements to occur in the two outside lanes. The most recent WisDOT counts for Lime Kiln indicated that traffic volumes on the street's north and south legs were below 13,000 vehicles per day, so the inside lanes could be devoted to left turns without seriously compromising the street's capacity. Methods of reducing the number of intoxicated drivers leaving area taverns should also be explored to further reduce the likelihood of crashes at the intersection.

14. West Mason Street/Military Avenue (Green Bay)

Crash Rate	1.37
Reportable Crashes Per Year	20.3
Est. Property Damage Cost/Year	\$129,920
Injuries Per Year	18.3
Est. Injury Cost/Year	\$624,030
Crash Type	
Right Angle	39%
Rear End	49%
Side Swipe	5%
Head On	2%
Bicycle/Pedestrian	0%
Other	5%
Driver Factor	
Disregard Traffic Control	15%
Failure To Yield	25%
Inattentive Driving	25%
Too Fast For Conditions	8%
Driver Condition	2%
Other*	25%



*The predominant Other factor was following too close.

Comments: The most common incidents at the West Mason/Military intersection were rear end crashes that resulted from motorists following too closely and driving inattentively. The rear end crashes also resulted in more than half of the injuries at the intersection and were evenly distributed between the eastbound, westbound, and northbound approaches. Since many of these crashes occurred on Mason Street during the weekday peak travel periods, it is possible that they were caused by motorists concentrating on making it through the lights at Fisk and Mitchell and not stopping fast enough to avoid the long queues at Military that are suddenly created by traffic spilling onto Mason from the many driveways. It is also possible that many of the Mason crashes resulted from motorists accelerating when the Military light turned green and having to suddenly decelerate when the light turned red again.

The intersection also experienced several angle crashes that occurred when left turning motorists were hit by motorists traveling through the intersection. Most of the left turning motorists were traveling eastbound and southbound prior to their turns, and only one northbound left turning vehicle was hit during the three year period. The latter statistic supports the assumption that a left turning driver's inability to see oncoming traffic is a significant factor in many angle crashes, for the Military Avenue hill north of Mason Street allows southbound motorists and northbound left turners to clearly see each other prior to the intersection. Left turning motorists at the other approaches, however, have a much more difficult time seeing oncoming traffic and are much more likely to cause angle crashes.

Recommendations: To slow motorists down, reduce weaving, and minimize driver confusion on Military, the city should consider narrowing the street to four lanes between 9th Street and Dousman Street. The 1998 counts for this segment of Military indicated that daily traffic volumes did not exceed 19,000 at any count station, and four lanes can easily handle this amount of traffic. The extra space at the Mason intersection could then be used to create offset left turn lanes that would enable left turning motorists to see oncoming vehicles

and offer pedestrians a refuge when crossing the wide intersection. This narrowing project would improve safety at other Military intersections as well.

To improve safety on Mason Street, the city should consider constructing offset left turn lanes like the ones recommended for Military and other intersections in the study. The city should also attempt to reduce the number of conflicts along Mason Street by working with the merchants along Mason between Fisk Street and Mitchell Street to develop shared driveways.

15. Main Street/Monroe Avenue (Green Bay)

Crash Rate	1.30
Reportable Crashes Per Year	6.7
Est. Property Damage Cost/Year	\$42,880
Injuries Per Year	2.3
Est. Injury Cost/Year	\$78,430
Crash Type	
Right Angle	70%
Rear End	15%
Side Swipe	5%
Head On	0%
Bicycle/Pedestrian	0%
Other	10%
Driver Factor	
Disregard Traffic Control	30%
Failure To Yield	35%
Inattentive Driving	10%
Too Fast For Conditions	5%
Driver Condition	0%
Other	20%



Comments: Many of the incidents at this intersection were caused by Main Street motorists disregarding the traffic controls, but the rest resulted from several different driver errors. The planned narrowing of Main Street might reduce vehicle speeds on Main and make drivers more reluctant to try to beat the traffic light at Monroe. The narrowing project will also provide an opportunity to create offset left turn lanes on Main to enable motorists to easily see oncoming vehicles (see Figure 1).

Recommendations: When Main is narrowed, the city should construct offset left turn lanes to maximize traffic visibility for left turning motorists. The island created by the offset lanes should also be large enough to serve as a pedestrian refuge.

15. Walnut Street/Jefferson Street (Green Bay)

Crash Rate	1.30
Reportable Crashes Per Year	8
Est. Property Damage Cost/Year	\$51,200
Injuries Per Year	8.7
Est. Injury Cost/Year	\$296,670
Crash Type	
Right Angle	67%
Rear End	16%
Side Swipe	4%
Head On	0%
<u>Bicycle/Pedestrian</u>	13%
Other	0%
Driver Factor	
Disregard Traffic Control	50%
Failure To Yield	21%
Inattentive Driving	9%
Too Fast For Conditions	4%
Driver Condition	0%
Other	16%



Comments: The most common incidents at this intersection were angle crashes that occurred when motorists on Walnut Street disregarded the traffic signal and hit motorists traveling south on Jefferson Street. All of the rear end crashes recorded at the intersection during the three year period also occurred on Walnut Street. The three pedestrian and bicycle crashes appear to have been caused by people walking and bicycling against the signal.

Similar to the situation at Cherry/Monroe prior to Cherry's conversion to a two way street, a typical crash at the Walnut/Jefferson intersection was probably one that happened when an eastbound or westbound motorist tried to beat the red light, wound up running it, and hit a southbound motorist as the motorist was accelerating into the intersection as soon as the light turned green. The high speeds on Walnut and rapid acceleration of vehicles from Jefferson left motorists very little time to avoid the crashes. The rear end crashes on Walnut also suggest that motorists on this street were anxious to stop at as few lights as possible between Monroe Avenue and Washington Street.

Recommendations: Since the reduction of crashes at the Cherry/Monroe intersection probably has a lot to do with Cherry Street's conversion to a two way street, it is recommended that Jefferson Street be slightly narrowed and converted to a two way street as well. In addition to encouraging vehicles to enter the intersection more slowly because of the presence of opposing traffic, the narrowing and conversion to two directional traffic will improve downtown circulation and make the intersection easier for pedestrians to negotiate.

17. Military Avenue/Leo Street (Green Bay)

Crash Rate	1.25
Reportable Crashes Per Year	10

Est. Property Damage Cost/Year	\$64,000
Injuries Per Year	9
Est. Injury Cost/Year	\$306,900
Crash Type	
Right Angle	74%
Rear End	10%
Side Swipe	3%
Head On	0%
<u>Bicycle/Pedestrian</u>	10%
Other	3%
Driver Factor	
Disregard Traffic Control	50%
Failure To Yield	10%
Inattentive Driving	27%
Too Fast For Conditions	0%
Driver Condition	0%
Other	13%



Comments: The most common incidents at this intersection were angle crashes that occurred when northbound and southbound motorists on Military Avenue disregarded the traffic signal and hit eastbound and westbound Leo motorists, and most of the Military violators were traveling north prior to the crashes. These crashes likely occurred because the traffic signals at the Leo intersection are dim, the signals are difficult to identify (the mast arms barely extend over Military Avenue's outside lanes), speeds on Military are relatively high, and many motorists on Military do not expect to encounter a set of signals so close to the Shawano Avenue intersection.

Recommendations: The city should increase the visibility of the Leo Street signals by extending the mast arms farther over the northbound and southbound Military Avenue lanes and replacing the dim signals with new ones that are easily seen. The city should also narrow Military Avenue between 9th and Dousman for the reasons identified in the West Mason/Military intersection recommendations.

17. Walnut Street/Madison Street (Green Bay)

Crash Rate	1.25
Reportable Crashes Per Year	7.7
Est. Property Damage Cost/Year	\$49,280
Injuries Per Year	8.7
Est. Injury Cost/Year	\$296,670
Crash Type	
Right Angle	70%
Rear End	17%
Side Swipe	4%
Head On	0%
Bicycle/Pedestrian	0%
Other	9%
Driver Factor	
Disregard Traffic Control	44%
Failure To Yield	13%
Inattentive Driving	26%
Too Fast For Conditions	0%
Driver Condition	0%
Other	17%



Comments: The most common (and severe) incidents at this intersection were angle crashes that occurred when a motorist disregarded the traffic signal. The distribution of these violations was fairly even, but more of these crashes were caused by eastbound motorists than by motorists from the other two approaches. The next most severe incidents over the three year period were angle crashes that were caused by motorists driving the wrong way (southbound) on Madison Street. There were also a few rear end crashes at the intersection between 1997 and 1999.

Recommendations: The number of crashes at the intersection would probably decrease if Madison were narrowed and converted to a two directional facility because opposing traffic and increased side friction would likely slow the Madison motorists down, encourage them to enter Walnut Street more cautiously, and make them less likely to try to beat the light. The crashes caused by people driving the wrong way on Madison would also be eliminated if the street is converted to two directions.

19. Cormier Road/Holmgren Way (Ashwaubenon)

Crash Rate	1.23
Reportable Crashes Per Year	7
Est. Property Damage Cost/Year	\$44,800
Injuries Per Year	4
Est. Injury Cost/Year	\$136,400
Crash Type	
Right Angle	76%
Rear End	14%
Side Swipe	5%
Head On	5%
Bicycle/Pedestrian	0%
Other	0%
Driver Factor	
Disregard Traffic Control	9%
Failure To Yield	63%
Inattentive Driving	9%
Too Fast For Conditions	0%
Driver Condition	0%
Other	19%



Comments: The number of crashes and injuries at the Cormier/Holmgren intersection was reduced after signals were installed at the beginning of 1998. The most common problem now appears to be collisions that occur when vehicles traveling straight hit vehicles making left turns.

Recommendations: The intersection should be monitored over the next few years to determine how the new signals have affected traffic safety.

20. Monroe Avenue/Porlier Street (Green Bay)

Crash Rate	1.19
Reportable Crashes Per Year	9.3
Est. Property Damage Cost/Year	\$59,520
Injuries Per Year	6
Est. Injury Cost/Year	\$204,600
Crash Type	
Right Angle	79%
Rear End	11%
Side Swipe	7%
Head On	0%
Bicycle/Pedestrian	0%
Other	3%
Driver Factor	
Disregard Traffic Control	0%
Failure To Yield	79%
Inattentive Driving	3%
Too Fast For Conditions	3%
Driver Condition	0%
Other	15%



Comments: Most of the crashes at this intersection occurred when a northbound or southbound vehicle hit another vehicle as it was turning left onto Porlier. These crashes were likely the result of left turners not being able to see vehicles approaching the intersection in the outside lanes because an opposing vehicle was also waiting to make a left turn.

Recommendations: Assuming this was (and is) the problem, the ideal solution is to stagger the left turning vehicles so approaching vehicles can be seen well before reaching the intersection (see Figure 1). However, this could only be accomplished by restricting the two inside lanes of Monroe to left turns and forcing all through and right movements to occur in the two outside lanes.

20. Ashland Avenue/Hansen Road (Ashwaubenon)

Crash Rate	1.19
Reportable Crashes Per Year	11.7
Est. Property Damage Cost/Year	\$74,880
Injuries Per Year	8.3
Est. Injury Cost/Year	\$283,030
Crash Type	
Right Angle	57%
Rear End	34%
Side Swipe	3%
Head On	0%
Bicycle/Pedestrian	0%
Other	6%
Driver Factor	
Disregard Traffic Control	6%
Failure To Yield	51%
Inattentive Driving	20%
Too Fast For Conditions	6%
Driver Condition	3%
Other	14%



Comments: This intersection experienced several angle and rear end crashes that were caused by several different factors over the three year study period, but the most common incidents were angle crashes that occurred when left turning Ashland motorists were hit by motorists traveling north and south on Ashland. As was likely the case at many other intersections addressed in this study, these crashes were probably the result of left turners not being able to see vehicles approaching the intersection in the outside lanes because opposing vehicles were also waiting to make left turns.

Recommendations: Many of the crashes and injuries at the intersection would likely be eliminated by constructing offset left turn lanes in the existing Ashland Avenue medians (see Figure 1). This project should be relatively inexpensive because adequate space exists between the northbound and southbound lanes, and the money saved by reducing crashes and injuries at the intersection would pay for the improvements in very little time.

22. East Mason Street/Bellevue Street (Green Bay)

Crash Rate	1.18
Reportable Crashes Per Year	13.7
Est. Property Damage Cost/Year	\$87,680
Injuries Per Year	12.3
Est. Injury Cost/Year	\$419,430
Crash Type	
Right Angle	51%
Rear End	29%
Side Swipe	2%
Head On	10%
<u>Bicycle/Pedestrian</u>	6%
Other	2%
Driver Factor	
Disregard Traffic Control	20%
Failure To Yield	43%
Inattentive Driving	15%
Too Fast For Conditions	0%
Driver Condition	7%
Other	15%



Comments: The East Mason/Bellevue intersection experienced a variety of different crashes during the three year study period, but the most common incident at this intersection was an angle crash that occurred on Mason Street when a left turning vehicle was hit by an oncoming vehicle. The intersection's rear end crashes occurred exclusively on Mason Street, and they were almost evenly distributed between the eastbound and westbound approaches. There were also seven crashes and nine injuries attributable to alcohol-related incidents at the intersection.

Mason Street currently does not have a left turn lane at the westbound approach. This is likely a peak hour hazard for some eastbound motorists that turn left (north) onto Bellevue Street because those that miss the protected left turn arrow have a difficult time seeing traffic approaching in the outside westbound lane when a westbound left turner is waiting to turn. This situation likely causes many (if not all) of the eastbound left turning crashes at the intersection.

Recommendations: A possible remedy to the eastbound left turning issue would be to extend the protected left turn phase during the peak hours. If this does not work, the city should consider building offset left turn lanes at each approach if the space is available to allow turners to see opposing vehicles approaching the intersection. The project's cost should not be an issue, for the money saved by significantly reducing crashes and injuries at the intersection would pay for the improvements in very little time.

23. Walnut Street/Washington Street (Green Bay)

Crash Rate	1.17
Reportable Crashes Per Year	8
Est. Property Damage Cost/Year	\$51,200
Injuries Per Year	6.3
Est. Injury Cost/Year	\$214,830
Crash Type	
Right Angle	33%
Rear End	42%
Side Swipe	12%
Head On	8%
Bicycle/Pedestrian	0%
Other	5%
Driver Factor	
Disregard Traffic Control	24%
Failure To Yield	5%
Inattentive Driving	33%
Too Fast For Conditions	33%
Driver Condition	0%
Other	5%



Comments: The most common (and severe) incidents at this intersection were rear end crashes that occurred when motorists on Walnut Street were driving inattentively or too fast during poor weather conditions. The data suggest that many of these crashes happened when motorists traveling east over the Walnut Street bridge were unable to stop before hitting vehicles stopped at the Washington Street light. Many of the crashes that happened during bad weather might have been a result of eastbound motorists skidding down the hill between the bridge and Washington Street.

Recommendations: Perhaps the city can post signs at the bridge's east and west approaches that warn drivers of possible queues and tell them to proceed with caution over the bridge (especially during bad weather).

24. University Avenue/Baird Street (Green Bay)

Crash Rate	1.10
Reportable Crashes Per Year	5.3
Est. Property Damage Cost/Year	\$33,920
Injuries Per Year	5.7
Est. Injury Cost/Year	\$194,370
Crash Type	
Right Angle	63%
Rear End	25%
Side Swipe	6%
Head On	6%
Bicycle/Pedestrian	0%
Other	0%
Driver Factor	
Disregard Traffic Control	25%
Failure To Yield	44%
Inattentive Driving	12%
Too Fast For Conditions	19%
Driver Condition	0%
Other	0%



Comments: The most common incidents at this intersection were angle crashes that occurred on University Avenue when left turning vehicles were hit by oncoming vehicles. These crashes likely occurred because speeds on University are relatively high and it is difficult for left turning motorists to see approaching vehicles if an opposing vehicle is also waiting to make a left turn. The University/Baird intersection also experienced four alcohol-related crashes during the three year study period, and poor driving conditions appear to have contributed to some of the crashes.

Recommendations: Nearly 50 percent of the crashes at the University/Baird intersection would likely be eliminated if offset left turn lanes were constructed to allow turners to see opposing vehicles approaching the intersection, so Green Bay should determine if this project is feasible and proceed with the project if it is. The project's cost should not be an issue, for the money saved by significantly reducing crashes and injuries at the intersection would pay for the improvements in very little time.

24. Webster Avenue/Walnut Street (Green Bay)

Crash Rate	1.10
Reportable Crashes Per Year	8.7
Est. Property Damage Cost/Year	\$55,680
Injuries Per Year	9.7
Est. Injury Cost/Year	\$330,770
Crash Type	
Right Angle	58%
Rear End	23%
Side Swipe	8%
Head On	0%
<u>Bicycle/Pedestrian</u>	3%
Other	8%
Driver Factor	
Disregard Traffic Control	35%
Failure To Yield	8%
Inattentive Driving	31%
Too Fast For Conditions	3%
Driver Condition	0%
Other	23%



Comments: This intersection experienced a variety of crashes that were caused by a variety of factors between 1997 and 1999, but the most common (and severe) incidents were angle crashes caused by motorists disregarding the traffic signal at all four approaches. Although only one southbound motorist caused a crash by disregarding the signal, southbound motorists were responsible for all of the rear end crashes on Webster and for the majority of rear end crashes at the entire intersection during the three year study period. The intersection also experienced a relatively high number of crashes while the traffic signals were in flash mode, for four of the ten crashes that occurred between midnight and noon happened when the signals were flashing.

Recommendations: Since the signals are easily seen from all directions and the number of crashes at the intersection in 1999 was significantly lower than the two previous years, it is possible that the dangerous conditions that existed in the past no longer exist. To determine if the intersection is safer than in the past, crash statistics for 2000 and 2001 should be studied when they are available.

26. Lombardi Access/Marlee Lane (Ashwaubenon)

Crash Rate	1.06
Reportable Crashes Per Year	5.3
Est. Property Damage Cost/Year	\$33,920
Injuries Per Year	2.3
Est. Injury Cost/Year	\$78,430
Crash Type	
Right Angle	75%
Rear End	6%
Side Swipe	13%
Head On	6%
Bicycle/Pedestrian	0%
Other	0%
Driver Factor	
Disregard Traffic Control	6%
Failure To Yield	76%
Inattentive Driving	6%
Too Fast For Conditions	6%
Driver Condition	0%
Other	6%



Comments: The most common incidents during the three year period were angle crashes that occurred when westbound frontage road vehicles tried to cross Marlee and were hit by vehicles traveling south through the Lombardi intersection. These and a few other types of crashes at the intersection suggest that it is very difficult for vehicles stopped at the south, east, and west approaches to accelerate through the wide intersection to avoid vehicles traveling through the green light at Lombardi.

Recommendations: It appears that at least half of the crashes that occurred at the intersection could have been avoided if vehicle movements across Marlee on the frontage road had been prohibited, the intersection were smaller, and vehicle speeds were lower. A roundabout at this intersection would solve many of its problems, but it would not likely function efficiently unless a large six leg roundabout is built that includes the Lombardi/Marlee intersection.

27. West Mason Street/Hinkle Street (Green Bay)

Crash Rate	1.03
Reportable Crashes Per Year	14.3
Est. Property Damage Cost/Year	\$91,520
Injuries Per Year	8.7
Est. Injury Cost/Year	\$296,670
Crash Type	
Right Angle	33%
Rear End	47%
Side Swipe	14%
Head On	2%
Bicycle/Pedestrian	0%
Other	4%
Driver Factor	
Disregard Traffic Control	4%
Failure To Yield	26%
Inattentive Driving	23%
Too Fast For Conditions	9%
Driver Condition	4%
Other	34%



Comments: The most common incidents at this intersection were rear end crashes on Mason Street that occurred when motorists were driving inattentively or were following other motorists too closely. The intersection also experienced several left turning angle and side swipe crashes, and more than half of the crashes during the three year study period happened on a Friday, Saturday, or Sunday.

The left turning angle and side swipe crashes on Mason Street would likely be eliminated by installing offset left turn lanes in the Mason medians, but the rear end crashes will likely continue unless traffic levels decrease or vehicle speeds are reduced. However, reducing speeds on this segment of Mason Street will be very difficult because it is very wide and invites motorists to drive fast. The roundabouts recommended for the Mason/Taylor intersection earlier in the study combined with roundabouts at the Mason/US 41 interchange would likely reduce speeds east of the Mason/Hinkle intersection, but most of the rear end crashes on Mason Street were caused by eastbound drivers as they approached the intersection from the west.

Recommendations: Offset left turn lanes should be constructed in the Mason medians to enable left turning motorists to clearly see oncoming traffic (see Figure 1). Roundabouts at the US 41/Mason Street interchange should also be considered to slow traffic in the area and hopefully reduce the number of rear end crashes. It is also possible that Mason's outside lanes could be eliminated if roundabouts are built at the interchange, which would increase side friction and reduce speeds.

28. Main Street/Baird Street (Green Bay)

Crash Rate	1.01
Reportable Crashes Per Year	9
Est. Property Damage Cost/Year	\$57,600
Injuries Per Year	5
Est. Injury Cost/Year	\$170,500
Crash Type	
Right Angle	67%
Rear End	12%
Side Swipe	7%
Head On	7%
Bicycle/Pedestrian	0%
Other	7%
Driver Factor	
Disregard Traffic Control	26%
Failure To Yield	37%
Inattentive Driving	7%
Too Fast For Conditions	7%
Driver Condition	7%
Other	16%



Comments: The most common incidents at this intersection during the three year period were angle crashes that happened when vehicles traveling straight hit vehicles making left turns, and nearly all of the left turners were traveling westbound or southbound when they were hit. Also, all of the motorists that were cited for disregarding the traffic signal on Main were traveling eastbound prior to the crashes.

Recommendations: An effective method of reducing (or possibly eliminating) the left turn crashes at the intersection would be to construct offset left turn lanes at all four approaches, and the space necessary to add these offset lanes appears to be available at the Main approaches and possibly at the Baird approaches. This intersection could also be made more safe, accessible, and attractive with a roundabout, but it is possible that existing traffic volumes would strain the capacity of a single lane facility.

29. Main Street/Elizabeth Street (Green Bay)

Crash Rate	.99
Reportable Crashes Per Year	6.7
Est. Property Damage Cost/Year	\$42,880
Injuries Per Year	3
Est. Injury Cost/Year	\$102,300
Crash Type	
Right Angle	45%
Rear End	30%
Side Swipe	5%
Head On	0%
Bicycle/Pedestrian	0%
Other	20%
Driver Factor	
Disregard Traffic Control	15%
Failure To Yield	20%
Inattentive Driving	5%
Too Fast For Conditions	20%
Driver Condition	5%
Other	35%



Comments: The most common incidents at this intersection were angle crashes that occurred when westbound motorists turned left in front of eastbound motorists and eastbound rear end crashes. There were also several alcohol-related crashes at or near the intersection, and more than half of the crashes happened on a Saturday or Sunday. However, all of the crashes occurred in 1997 and 1998, which suggests that the Main Street reconstruction project made the intersection much safer.

Recommendations: Since it appears that the reconstruction project made the intersection safer, the intersection should be monitored over the next few years to see if it remains safe.

29. Monroe Avenue/Walnut Street (Green Bay)

Crash Rate	.99
Reportable Crashes Per Year	8.3
Est. Property Damage Cost/Year	\$53,120
Injuries Per Year	4.3
Est. Injury Cost/Year	\$146,630
Crash Type	
Right Angle	32%
Rear End	36%
Side Swipe	16%
Head On	0%
<u>Bicycle/Pedestrian</u>	8%
Other	8%
Driver Factor	
Disregard Traffic Control	12%
Failure To Yield	20%
Inattentive Driving	24%
Too Fast For Conditions	4%
Driver Condition	0%
Other/Blank	40%



Comments: This intersection experienced a variety of crashes that were caused by a variety of factors between 1997 and 1999, but the most common incidents were angle and rear end crashes caused primarily by southbound and eastbound motorists that had failed to yield or were driving inattentively. The crashes were also fairly evenly distributed throughout the week and occurred at all times of the day.

Recommendations: Perhaps the signals could be timed to allow the southbound and eastbound vehicles to clear the Walnut and Monroe corridors without trying to beat the lights, but this would be difficult since both streets are arterials.

IV. Conclusions

The statistics for the 30 intersections in this study suggest that most of the crashes that occurred between 1997 and 1999 were the result of only a handful of problems. For example, every intersection experienced at least a few crashes that were likely caused by the inability of turning motorists to see oncoming motorists, and this was probably the primary cause of the majority of crashes at several of the intersections. All of the intersections in the study also experienced crashes attributable to drivers disregarding traffic signals or stop signs, and most of these incidents were probably the result of people failing to beat red lights or simply not seeing the signal or sign until it was too late. Rear end crashes were very common, and in most cases these crashes appeared to have been caused by drivers not paying attention, following the vehicles in front of them too closely, and driving too fast in all types of weather. There were several crashes that did not fit into these categories, but these seemed to be the most common crashes at the 30 metropolitan area intersections during the three year study period.

Since most of the crashes appear to fit into one of the categories listed above, it should be reasonably easy to correct the problems and significantly reduce the number of crashes in the area. The intersection summaries presented in Section III of the study recommended several methods of improving safety, but the more frequent recommendations are also discussed below.

Roundabouts

Roundabouts are recommended at several intersections in the study because they can significantly reduce the number and severity of the types of crashes that were common at these intersections (e.g. right angle crashes and crashes caused by people disregarding traffic controls), enhance traffic capacity, maximize safety and accessibility for pedestrians and bicyclists, and improve the attractiveness of an area. In many cases, roundabouts are less expensive to build than new or expanded signalized intersections and allow streets that would ordinarily be expanded for vehicle storage to remain narrow because traffic is able to flow virtually uninterrupted. The reduction in property damage and injury costs at many of the intersections in the study would likely cover the cost of the roundabouts in very little time.

Single lane roundabouts have proven to be very safe, efficient, and attractive throughout the world. The Lineville Road roundabouts in Howard have undoubtedly improved flow, safety, and accessibility, and many people that initially opposed their installation have become roundabout supporters (see Figure 2 for a picture of the Lineville Road/Cardinal Lane roundabout). Roundabouts with more than one lane, however, are still untested locally and are encountering a lot of the same opposition that the single lane roundabouts faced in 1998 and 1999. Even though the safety benefits have not been as significant as those attributable to single lane facilities, two lane roundabouts have still reduced crash frequency and substantially reduced crash severity after they replaced large signalized intersections, and they are much more pedestrian friendly than many multi-lane signalized crossings.

The benefits of two lane roundabouts are mentioned here because these larger facilities will likely be necessary if roundabouts are chosen at the intersections of Lombardi Avenue and Marlee Lane, West Mason Street and Taylor Street, and other high volume arterial intersections in the area. Roundabouts were recommended at these heavily traveled intersections because they experienced several severe crashes during the three year study period that could be eliminated by roundabouts. Larger roundabouts are also a logical method of reducing the dangers associated with frontage roads that connect to major streets very close to large intersections, for they significantly reduce conflicts and speeds and make the intersection much less confusing. The large roundabouts would not eliminate crashes at the large intersections, but the number of crashes would decrease and the severity of the crashes that occur would be low.

Offset Left Turn Lanes

The offset left turn lanes that are illustrated in Figure 1 and recommended for many intersections in the study would significantly improve the ability of left turning motorists to see oncoming vehicles and, as a result, likely reduce crashes at many of the intersections included in this study. These relatively low cost methods of improving safety could be easily installed using the medians on Ashland Avenue, West Mason Street, Lombardi Avenue, and other major streets in the area that experienced several left turning crashes between 1997 and 1999. The islands that separate the left turn lanes from the through lanes would also serve as pedestrian refuges for people crossing the wide and heavily traveled streets.

Jefferson Street and Madison Street Traffic Flow and Width Revisions

The study recommends that Jefferson Street and Madison Street be converted to two directional streets and cites the Cherry Street conversion as evidence that this action will reduce crashes. The Jefferson and Madison conversions are already recommended in Green Bay's Downtown Design Plan and could occur without affecting each street's existing ramp connection to Mason Street. The study also recommends that the streets be slightly narrowed to further reduce vehicle speeds and improve safety.

Both of these corridors contain schools, parks, and other destinations that attract people of all ages that use a variety of transportation modes. An example of a street design that would improve vehicle circulation, slow traffic, and reduce exposure for pedestrians and motorists that want to cross Jefferson and Madison would be a two lane street that allows parking on both sides and contains curb extensions at each intersection (this is illustrated in Figure 3). This type of design is used throughout the country to improve safety and access for motorists and non-motorists and would work well on Jefferson and Madison. This design would also likely reduce the need for police officers to enforce speed limits on Madison Street near Howe Elementary School and allow the officers to concentrate on other problem areas.

Frontage Roads

Some of the intersections in the study contain frontage roads on one or both sides of arterial streets that connect very close to the main intersections. The crash data and field reviews suggest that vehicle movements to and from the frontage roads make the intersections very dangerous at peak travel times and moderately dangerous during off-peak times. Unfortunately, the problems posed by the existing frontage roads are very difficult to fix because existing buildings make it nearly impossible to move the connection points farther away from the intersections. Since the connection points cannot be moved, the only way to reduce crashes at the frontage roads would be to restrict vehicle movements to and from the roads or make the existing movements safer.

The study recommends that frontage road movements at the West Mason Street/Packerland Drive and Main Street/Auto Plaza Way intersections be restricted to improve safety, which theoretically would reduce the number of crashes at the intersections. However, this would likely prompt drivers to cut through parking lots, make Uturns in traffic, and take other illegal and dangerous actions to minimize the “inconvenience” created by the frontage road restrictions. This probable reaction to the restrictions is one of the reasons the study recommends a six leg roundabout at the Lombardi Avenue/Marlee Lane intersection that would include both Lombardi approaches, both Marlee approaches, and both Lombardi Access approaches. In addition to maximizing convenience, the roundabout would likely be the most efficient and safe means of correcting many of the problems that exist at the two closely spaced intersections. The Mason/Packerland and Main/Auto Plaza Way intersections could also be converted to eight leg roundabouts (which do exist), but this would likely be very confusing for local drivers and should not be attempted until people become familiar with two lane roundabouts with fewer approaches. As complicated as a six (or more) leg roundabout sounds, its ability to accommodate several street approaches at one intersection makes it the safest and most efficient method of correcting the problems created by frontage roads that connect too close to major intersections.

If frontage roads are considered for other streets in the future, they should be constructed as far away from the main intersections as possible. If, however, frontage roads absolutely have to be connected close to intersections, multi-leg roundabouts should also be constructed to maximize safety and efficiency.

V. Implementation

This study identifies safety problems at several intersections, identifies the estimated property damage and injury costs associated with these problems, and recommends remedies to the problems that would likely be paid for by the cost savings associated with the resulting crash and injury reductions. For instance, a 30 percent crash and injury reduction at the intersection of Lombardi Avenue and Marlee Lane could reduce the intersection’s property damage and injury costs by more than \$220,000 per year, and this savings could be even greater if the most severe crashes are reduced or eliminated. If each of the intersections in this study were to realize similar crash reductions, property damage and injury costs would decline by several millions of dollars every year.

The financial impact of improving safety at these and other intersections in the area would be very significant, but the most important reason to make intersections as

hazard-free as possible is to protect the drivers, pedestrians, bicyclists, and other users of the transportation system from injury. After all, a dented fender can be fixed, but many injuries never completely heal. To provide everyone safer access to a variety of destinations, the study should be used by the affected communities, Brown County Highway Department, and Wisconsin Department of Transportation as a means of identifying the existence of hazards, determining why the hazards exist, and financially justifying corrections that will reduce or eliminate the hazards.